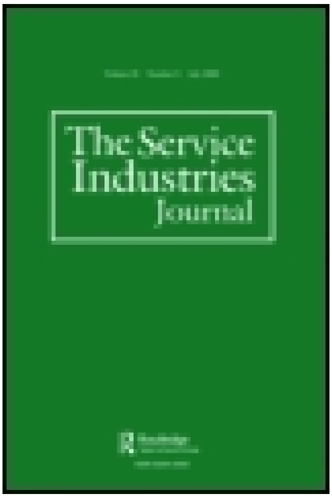

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Do innovation spillovers impact employment and skill upgrading?

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So far, the research on impact of innovation on employment and skills focused on effects within firms and sectors. Little attention was paid to the influence of interlinkages between sectors as a source of employment change. The main contribution of this paper to the field refers to broadening the analysis of innovation impacts to innovation spillovers from vertically linked sectors on firms' employment and skill change in user industries. The empirical analysis conclusively demonstrates an important role of innovation spillovers in the economy. Firms' employment growth is shown to benefit significantly from spillovers of product innovations in manufacturing and knowledge-intensive services. Similarly, firms that are subject to increased spillovers of product innovations as well as marketing and organisational innovations are more likely to upgrade their skill composition. Conversely, employment growth and skill composition of firms seem to be negatively affected by spillovers of process innovations in vertically linked sectors.

Keywords: innovation; spillovers; employment; skills; knowledge intensive services

Introduction

Service industries dominate the employment landscape in all European economies where the bulk of new jobs are created in the service sector. These facts are highly relevant when considering the drivers of employment change and skills composition, innovation being among highly important drivers. The link between innovation and employment was for long studied from the perspective of labour-saving impacts of the technological change that improved efficiency of production processes and decreased the demand for labour (Freeman & Soete, 1987; Pianta, 2005; Spiezia & Vivarelli, 2002). Later on, a number of studies pointed to differences between product and process innovation as well as to some differences between manufacturing and services sector in this respect (Evangelista & Vezzani, 2012; Harrison, Jaumandreu, Mairesse, & Peters, 2014). Broad dissemination of information and communications technology (ICT) triggered also the changes in organisational practices of firms that were reflected in the extension of research of innovation impacts to capture non-technological innovation as well. It is asserted that both the technological (product, process) and non-technological innovation (organisational) bear positive indirect effect on employment through increased sales of firms (Evangelista & Vezzani, 2012). With ICT-induced innovation, the impact on skills and workforce quality became highly relevant as illustrated by the tendency towards replacing low-

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skilled employees with high-skilled employees (see detailed discussion in Vivarelli, 2014). Furthermore, the upskilling trend appears to be also a function of organisational change that is related and combined with the technological change (Piva, Santarelli, & Vivarelli, 2005). Even though the availability of sophisticated technical skills may prevail in generating some services, soft skills and social sciences-related knowledge is of utmost importance to integrate and use efficiently new technologies. Knowledge-intensive business services and organisational innovations will play an essential role in translating the potential of new technology into innovation and market success (Gallouj, Webber, Stare, & Rubalcaba, 2014).

On the whole, the exploration of relations between innovation and employment is very complex due to several dimensions, such as level of analysis (firm, industry, aggregate), type of innovation (technological, non-technological), innovation strategies, and so on or combinations thereof, causing ambiguities in understanding.[1] However, it appears that the analysis of innovation impacts on employment change and upskilling so far was carried out mainly from the perspective of effects within the firm, industry, or sector, paying little attention to the increasing interlinkages between sectors that affect production process. In this vein, Djellal and Gallouj (2007) observe that the discussion of the relation between innovation and employment in the context of service economy needs to take account of innovation in services and innovation by services industries, where services as inputs to other sectors may cause changes in employment. As a matter of fact, interlinkages between sectors/industries open up additional channel through which innovation in one sector/industry may influence employment in other sectors/industries.

The effects of innovation on employment were very rarely studied from the perspective of innovation spillovers from vertically linked industries. Upon this background, the main objective of this paper is to complement the research of innovation effects on employment by highlighting a new dimension that arises from knowledge externalities (spillover effects) of different types of innovation on employment and skills in vertically linked industries. This is considered the main theoretical contribution of the paper. Our hypothesis is that using innovative inputs from vertically linked sectors positively impacts employment and skills change, whereby the positive impacts should be larger from knowledge-intensive service industries. Service inputs are increasingly integrated into value creation in manufacturing and other activities with knowledge-intensive services[2] (KIS) playing especially important role by generating new knowledge, processing and diffusing it within the whole innovation systems (Miles, 2007). The suppliers of KIS transfer codified and tacit knowledge that provides problem-specific and innovative solutions to clients (Landry, Amara, & Doloreux, 2012). The research challenge for us is to explore how the knowledge through backward linkages (innovation in services and particularly in KIS) spills over and impacts the employment and skill change of firms in user industries (manufacturing).

We test the above hypothesis empirically by exploring the effect of innovative inputs on employment and skill changes in manufacturing firms using the data for a representative sample of Spanish firms for 1990–2008. Our results show that in particular product innovations in vertically linked manufacturing and service sectors positively stimulate employment growth of Spanish manufacturing firms. Spillovers of process innovations in manufacturing and service sectors, however, are shown to exert a negative effect. All of the positive spillover effects of product innovation in service industries are stemming from KIS industries, which in addition positively affect firms in user industries also through organisational and marketing innovations. In terms of skill upgrading, the results show that innovations in manufacturing sector do not have an impact on firms in vertically linked firms, while innovations in service sector play an important role. Again, product innovations and organisational and marketing innovations in KIS industries contribute positively to changes in skill composition of firms in vertically linked user industries. Spillovers of process innovations, on the other side, negatively affect skill upgrading of vertically linked firms. This calls for rethinking of the effects of innovation interlinkages across industries.

The outline of the paper is as follows. After the introduction, we discuss the conceptual approach to analysing the linkages between innovation and employment by presenting both the literature survey and the theoretical framework for analysis. Short overview of literature focuses on the analysis of impacts of technological and non-technological innovation on employment in services/manufacturing as well as on studies that examine the related skills changes. The discussion of conceptual framework based on endogenous growth theory presents a novel approach to the research of employment effects of innovation that refers to spillovers from vertically linked sectors. The third section discusses methodology, empirical model and data set used in econometric analysis. In the central section, we first replicate the analysis of the impact of different types of innovation in manufacturing on employment growth within a firm and align the results to previous studies; and secondly, we study how knowledge spillovers from vertically linked industries affect employment and skill changes in manufacturing firms where special attention is paid to KIS spillovers. In the concluding section, we summarise the results and discuss policy implications.

Conceptual approach for analysing the relations between innovation and employment

Literature review

The section briefly reviews the literature dealing with innovation and employment relation by taking into account effects of different types of innovation, implications for skills composition and spillover effects of using innovative inputs from vertically linked industries. At the outset, studies focused on differences between the impacts of product and process innovation. In general, it was found that product innovation increases employment in manufacturing while process innovation has negative effect on jobs (Pianta, 2005). Djellal and Gallouj (2007) observe that studies have generally claimed positive employment effects of product innovations in services owing to the broadening of services variety and to the opening up of new markets. To the contrary, process innovations seem more likely to downsize employment by improving the efficiency in services production and substituting labour with capital. However, Harrison et al. (2014) find no evidence of displacement effects from either type of innovation in the service sector. A broader perspective of implications of technological change on jobs creation/destruction in a comparative setting of manufacturing and service industries reveals that firms aiming at developing new products and markets (technological competitiveness) display significant positive effect on job creation. To the contrary, the strategy aiming at labour-saving processes (cost competitiveness) has a negative effect on employment (Bogliacino & Pianta, 2010). The study identifies important differences between four groups of industries irrespective of the sector[3] in respect of employment changes that are not only the result of innovation strategy followed (technological vs. cost competitiveness), but also of changes in demand, wages, competition, and firm dynamics.

For long, most studies analysing the relation between innovation and employment had a clear focus on technological innovation. Arguments in favour of including organisational innovation into analysis to better understand growth and employment effects of innovation were the exception (Edquist, Hommen, & McKelvey, 2001). Pianta (2005) argues that organisational innovation is frequently an indispensable complement to the adoption of new technologies. With the increasing weight of services in economies, it was recognised that some service industries innovate mainly via the adoption and application of new technology while other service industries are more prone to rely on non-technological types of innovation such as organisational changes (Vence & Trigo, 2009). Evangelista and Vezzani (2012) assert that all types of innovation (product, process, and organisational) bear positive indirect effect on employment through increased sales of firms in both services and manufacturing, while direct employment gains are achieved even if firms introduce only organisational innovations. They suggest that changes in the organisational structure and operational functioning of firms represent an autonomous and effective innovation mode. The strongest job creation effects occur in firms that combine product, process, and organisational innovation, highlighting the complementary nature of innovation types. The latter is confirmed also by studies exploring the impact of various innovation types on firm sales and productivity (Evangelista & Vezzani, 2010; Som & Diekmann, in press). Overall, it is important to emphasise that the link between innovation and employment varies at different levels of analysis (firm, industry, macro level) that needs to be taken into account when comparing the results of studies.

Intensive use of ICT across industries increased the interest for assessing the impact of technological change on skills and workforce quality. The evidence on the substitution of unskilled with skilled labour confirmed the skill-biased technological change hypothesis across countries, different economic sectors and different types of innovation (Evangelista & Savona, 2003). In services, the strength of this relation varies across service industries with largest upskilling effects in KIS (Bogliacino, Lucchese, & Pianta, 2013). Studies also indicate that efficient ICT deployment is associated with changes in different organisational dimensions requiring skilled workers (see Piva et al., 2005 and Vivarelli, 2014 for detailed discussion). Estimations for Italian manufacturing firms show that the upskilling trend of employment appears to be mainly a function of organisational change that exerts significant impact, possibly combined with technological change (Piva et al., 2005).

With few exceptions (Hollanders & Weel, 2002; Machin & Van Reenen, 1998), the literature treats the effects of innovation on employment/skill change inside the firms/industries/sectors only. However, technological progress and changes in the organisation of production processes require close and frequent interactions among actors from different constituencies. The innovation process in itself necessitates a broad range of knowledge, skills, and competences that are sourced internally and externally beyond the firm/industry/sector boundaries. They are complementary and can be combined throughout the value chain. The analyses that take account of interlinkages and spillover effects of innovation between vertically linked industries/sectors are so far concentrated on the implications on productivity of firms. A number of studies focus on the special role of KIS that create a virtuous circle, in which they learn from their clients, codify this knowledge and act as bridges between generic knowledge and the specific needs of the firms (Muller & Zenker, 2001), thereby fostering the innovation capacity throughout the economy (Gallouj, 2002). KIS display higher innovation intensity than manufacturing in most European Union economies. By introducing new or improved services, processes, and organisational and marketing innovations, the suppliers of tacit knowledge embodied in KIS complement internal innovation effort of firms and improve the performance of their clients. Firm-level analyses confirm knowledge spillovers from KIS and their facilitating role for innovation, productivity, and export performance of manufacturing firms (Doloreux & Shearmur, 2012). Recent empirical examination finds that not only the strength but also the innovative content of the linkages between KIS and user industries matter for the spillover effects of those industries on the value added of user industries[4] (Evangelista, Lucchese, & Meliciani, 2013). While the above analyses touch upon the effects of innovative KIS inputs for value creation in user industries, they do not say anything about the impact on employment of those industries. The latter is at the core of our analysis.

Theoretical framework

As far as the relation between technological change and employment is concerned, the major line of discussion at the outset was related to the introduction of labour-saving technologies that have an impact on production processes and labour requirements. This activates various compensation mechanisms whose interplay determines the net outcome on employment (see Freeman & Soete, 1987; Pianta, 2005; Spiezia & Vivarelli, 2002 for review of literature). Those mechanisms can stimulate demand from various sources, increase purchasing power, cause labour market adjustments and enhance employment via product innovation. While scholars addressing the link between technical change and employment examined the impacts on manufacturing, some of them considered that the gains of compensation mechanisms accrue much more to employment in services than in manufacturing (Petit & Soete, 2001; Spiezia & Vivarelli, 2002). The reasoning behind seems to be related to specific characteristics of services (intensity of labour use due to the importance of quality, the need for close interaction between service providers and users) on the one hand, and, on the other hand, to the role of ICT as the most important technology for services (e.g. endogenisation of ICT in the service economy, Djellal & Gallouj, 2007). However, large heterogeneity of services and their innovation patterns make it impossible to generalise the effects of innovation on employment in services. Moreover, innovation in services (and manufacturing) occurs not only due to technical change (product and process innovation), but also due to non-technological innovations (organisational and marketing changes) (Tether & Tajar, 2008).

Alongside the impact of different types of innovation on employment, their effects on skills change became increasingly recognised. The theoretical framework for analysing the nexus between innovation and employment was broadened by introducing the ‘skill-biased technological change hypothesis’. Grilliches (1969) suggested that efficient implementation of new technology requires workers with new and higher skills. Consequently, workers without such skills may increasingly become redundant. Nevertheless, broad dissemination of ICT stimulated also the adoption of innovative workplace practices and organisational models. Greenan (2003) link the up-skilling of labour to trend towards decentralisation of functions and responsibilities, combination of different skills and competencies, the diffusion of collaborative work practices. Those organisational changes produce similar effects on the demand for skilled labour as the technological innovation. However, scholars claimed that organisational change also has an independent role for skills change that leads to the emergence of ‘skill-biased organisational change hypothesis’. It is argued that productivity performance and wage differentials within and across firms reflect differences in the adoption of organisational practices (Bauer & Bender, 2004; Bresnahan, Brynjolfsson, & Hitt, 2002; Caroli & Van Reenen, 2001; Piva & Vivarelli, 2002).

Our approach to account for the importance of innovation spillovers on employment and skill composition of firms in user industries builds on the new growth theory that considers economic growth as determined mainly by endogenous sources. Apart from investment in innovation, human capital and knowledge, the endogenous growth theory points to the importance of knowledge externalities/spillovers across firms and industries for long-term economic growth (Romer, 1986). This channel of innovation effects on employment is largely missing from the analyses and presents a gap in understanding the phenomenon, particularly with respect to the increasing interlinkages between the sectors. Knowledge production generated by the firm extends beyond its boundaries to incorporate external sources of knowledge that spill over to firms using them and affect their performance, employment included. So far, the discussion on spillovers was extensively referred to in relation to spatial considerations that resulted in important insights. Audretsch and Feldman (2004) indicate that knowledge spillovers benefit from location and proximity that is observed in the formation of clusters and agglomerations. Bishop (2009) approached spillover effects from the perspective of service sector and found that the impact of local services spillovers on employment growth is heterogeneous for different service sectors. As a future direction of research, he suggests exploring the role of the service sector as a source rather than as a recipient of spillover effects.

The theoretical contribution of our analysis follows this direction by embedding the analysis of knowledge externalities (innovation spillovers) into the analysis of employment effects. The main novelty of the paper is the illustration of positive effects on employment and skill upgrading in manufacturing via spillovers from vertically linked innovative service industries. In practice, these spillovers are rather common when new ICT-enabled services are used in manufacturing. A case in place is Google advertising service (product innovation) that displays ads related to keywords of search result. Companies using these services benefit from making their products visible to a large number of interested customers that may increase sales of their products and also the employment. Another example of innovation spillovers relates to the introduction of online banking services that largely replaced the traditional over-the-counter banking services. This product innovation benefitted not only final consumers but predominantly companies with enormous time savings, once switching to online banking services. While there were probably some negative effects on employment in firms using the innovative banking services, it surely contributed to the changes in skill composition of labour in firms using these services.

New design (non-technological innovation) is increasingly important to differentiate products from those with identical technical characteristics and may also add a new functionality to the product. Such products attract different segments of consumers or make inroad into new markets that finally results in additional employment. The development of electronic design tools has had a wide application across various manufacturing industries, from apparel to transport equipment, which added benefits to firms in terms of cost reduction and improvement of overall quality of the product development cycle. But it is not only the availability of innovative electronic design tools in the design process that contributed to the efficiency of product development, but non-technological innovations are important as well. For instance, consider the spillover effect from non-technological innovation such as the new model of organisation developed by management consulting services and applied in manufacturing companies. For example, organisation of innovation process in manufacturing firm is changed in such a way that marketing and design experts are at the outset integrated with the team of engineers developing a new sailboat. Marketing and design experts can explore the needs of the potential buyers of sailboats and accommodate the final product to specific markets or trends (e.g. hybrid powered). The sale of those products is more likely to increase and also to boost employment, while it also requires hiring of skilled labour of different skill profiles in the process of designing the new products.

There is a wide range of innovations in various industries that are increasingly applied by firms in user industries. This suggests that those innovations spill over across industries enabling a substantial potential for revenues and productivity growth, while at the same time affecting the employment and skill composition of companies in vertically linked industries. It remains to be seen how important these innovation spillovers might be for employment and skill upgrading of firms. In the next section, we provide a methodology to account for innovation spillovers.

Methodology, empirical model and data set

In this section, we develop a novel methodology that enables to account for the effects of innovation spillovers on employment and skill upgrading of firms in vertically linked user industries. While the relevant literature so far focused only on impacts of firms' own innovation activities (and occasionally some spatial spillovers) on firms' employment, we claim that firms' employment and skill composition are influenced also by innovation spillover effects by using inputs of vertically linked innovative industries. These innovation spillovers stemming from manufacturing and service industries are likely to have an impact on employment and skill composition changes on all firms across the economy. Think of the whole range of innovation in the ICT, financial services, transport and machinery sector that emerged in the last two decades and that have changed the way how firms organise their product development processes, physical production, marketing and sales methods all over the economy. Most of the innovations that changed the landscape of production patterns originate outside the firms and outside of their industries

Empirical approach

We study the effects of innovation spillovers using a general framework that accounts both for the impact of firm own innovation as well as innovation spillovers from vertically linked manufacturing and services industries. To analyse the impact of innovation on individual firm's employment growth, we estimate the following model:

$$\Delta l_{ijt} = \alpha + \beta \cdot X^k_{ijt-2} + \delta \cdot Z^k_{mt-2} + \phi V_{ijt-2} + \varphi T + \gamma S + u_{it} + \varepsilon_{ijt}, \tag{1}$$

where Δl_{ijt} denotes our dependent variable, that is, firm's i employment growth.

Among explanatory variables, there are three groups of variables. X^k_{ijt-2} denotes a vector of firm's own innovation of type k, whereby k indicates three types of innovation: product only, process only, or product and process innovation that are lagged two years.[5] Using two lags enables us also to account for long-run effects that innovation exerts on employment and skill composition. The second group of variables is contained in the vector Z^k_{mt-2}, which denotes vertical innovation spillovers of type k stemming from different sectors m that are vertically linked to the industry j in which firm i is operating (where $j \neq m$). Here, j denotes two-digit industries according to Statistical Classification of Economic Activities in the European Community, Revision 1 (NACE Rev.1) and m stands for a broader sector such as manufacturing, services, or groups of services (KIS and less knowledge-intensive services (LKIS)).[6] Innovation spillover variable is described in greater detail below. The third group of explanatory variables V_{ijt-2} contains firm-level control variables such as size (measured by the number of employees) and productivity (measured by total factor productivity).[7] Both innovation spillovers and firm control variables are lagged two years in order to control for long-run effects of these variables on our dependent variables. Our model includes also year and sector fixed effects by including the vectors **T** (year) and **S** (NACE Rev.1) 2-digit industries). Finally, our model includes firm fixed effects u_i and the usual i.i.d. error term ε_{ijt}.

We explicitly account for potential vertical innovation spillovers from manufacturing and service industries where these serve as suppliers to industries in which particular firms operate. The rationale behind is that innovation by upstream industries can importantly affect performance of industries (and firms therein) that are more dependent on inputs from these particular industries. The higher the share of innovative firms in upstream industries and the higher the linkage between vertically linked industries, the higher is potential for downstream industries to benefit from innovation in upstream industries. We account for these backward vertical innovation spillover linkages by including a vector Z^k_{mt}, which denotes the weighted sum of shares of innovative firms in total population of firms in industry m (sIN^k_{mt}), where the weights are defined as the shares of the output of industries m purchased by firms in industry j (α_{mjt}). Innovation spillover variable is constructed using the following formula:

$$Z^k_{mt} = \sum\nolimits_{m,j=1}^{n} (\alpha_{mjt} \times sIN^k_{mt}),\ m, \quad j = 1, \ldots n, \tag{2}$$

where α_{mjt} ($0 \leq \alpha_{mjt} \leq 1$) is the proportion of industry m's output consumed by industry j. These direct input requirements are obtained in the form of corresponding technical coefficients from the country's input–output matrix for corresponding year. The share of innovative firms by industries is obtained from the Community innovation survey by country.

We estimate model (1) using ordinary least squares. We prefer this approach over the fixed-effects technique due to the fact that our dependent variable is specified in the first difference (growth rate), which means that the firm-specific fixed effects were differenced out. In addition, most of the explanatory variables are sector-specific and would hence be cancelled out with the fixed-effects transformation. We do, however, control for the possible remaining error due to firm fixed effects by including a set of firm-specific control variables such as size (in terms of number of employees) and productivity.

To analyse the impact of innovation on changes in firm's skill composition, we first estimate the model (1). We define firm's skill composition as the share of high-skilled labour (i.e. workers with at least 12 years of schooling) in total employment. There is, however, a problem with calculating changes in the share of high-skilled labour since a large number of small- and medium-sized firms start off with zero high-skilled labour. In these cases, growth rates of the high-skilled shares cannot be calculated leading to a number of missing observations. The second problem arises in cases of small firms reporting small number of high-skilled labour, where hiring one additional high-skilled worker leads to high growth rates in high-skilled shares. In order to avoid these complications and to economise with the number of observations, we define our second dependent variable denoting change in firm's skill composition as a binary response variable. Change in firm's skill composition is hence defined in the form of a binary indicator taking 1 if a firm has added at least one high-skilled worker between two consecutive years, and 0 otherwise.

When estimating model (1) using the binary indicator of change in skill composition as a dependent variable, we are effectively estimating the linear probability model (LPM). The LPM often serves as a convenient approximation to the underlying response probability when the latter behaves closely to the linear response probability for the common values of the underlying variable (see Wooldridge, 2010). Often, however, this is not the case. As a robustness check for our LPM results, we also estimate a probit model that explicitly takes into account a binary response nature of the dependent variable (hs_{ijt}). In doing so, we estimate the following probit model:

$$P(hs_{ijt} = 1) = \alpha + \beta \cdot X^k_{ijt-2} + \delta \cdot Z^k_{mt-2} + \phi V_{ijt-2} + \varphi T + \gamma S + u_{it} + \varepsilon_{ijt}. \tag{3}$$

All explanatory variables in the model are the same as in the model (1). The model is estimated using the fixed-effects probit specification.

Data

Effects of innovation spillovers on changes in employment and skill composition are estimated at the firm level. We estimate models (1) and (3) using firm-level accounting data and data on innovation activity and combine these data with the aggregate sector-level data on innovation of vertically linked sectors. We make use of a representative sample of survey data for Spanish manufacturing firms for the period 1990–2008. The data set from the Encuesta Sobre Estrategias Empresariales is an unbalanced sample of firms collected using direct interviews with a questionnaire. For firms with fewer than 200 employees, a random sample of survey participants was drawn ensuring the representativeness of the industrial and size categories. On the other hand, the total population of large firms, with at least 200 employees, was included in the survey. Our sample includes 34.748 firm-year observations with non-missing variables, ranging from 2178 to 2009 firm observations per year between 1990 and 2008. In addition to accounting data, the Encuesta Sobre Estrategias Empresariales also provides information on the innovative activity of manufacturing firms, and skill composition of employees. Unfortunately, the survey covers only technological innovation (product or process innovations). The data on skill composition (number of low- and high-skilled labour) are available only every four years (i.e. in 1990, 1994, 1998, 2002 and 2006). Employment is reported as full-time employees according to the number of working hours made by all employees as well as by particular skill type of workers. All value data were deflated using NACE 2-digit industry producer price indices, while the capital stock variable was deflated using the consumer price index.

To calculate vertical innovation spillover variables, we use sector-level data from the Community innovation survey and combine it with the data from the input–output tables. Community innovation survey data aggregated to the 2-digit NACE Rev.1 are available from the Eurostat for every second year. Note that Community innovation survey includes information on both technological (product, process) and non-technological (organisational, marketing) innovations, but the latter is available only after 2004. Input–output tables are also available from the Eurostat, but only for every five years. In order to fill the gaps in the data, we used the following approach. For the Community innovation survey data, we assumed that, according to the survey questionnaire, data at the end of the two-year period applies for the whole period. More precisely, Community innovation survey data from the 2008 survey are used for both 2007 and 2008, and similarly for the other Community innovation survey waves. For the input–output data, we assume fixed coefficients in between two subsequent input–output tables.

Descriptive statistics

Table 1 presents some descriptive statistics for the sample of Spanish firms in the period 1994–2006 by innovation type. On average, between 1994 and 2006, the number of employees of Spanish firms in the sample decreased by 18%, while the skill composition

Table 1. Descriptive statistics (total employment, share of high-skilled labour, and number of firms) in Spanish sample in the period 1994–2006 (by innovation type).

Innov. status	1994	2006	Change[a]
No inov.			
Total emp.	150.5	154.0	2.3
HS share[b]	28.5	28.7	0.2
No. firms	1023	1280	
Prod. inn. only			
Total emp.	371.9	274.1	−26.3
HS share[b]	37.6	36.9	−0.7
No. firms	194	181	
Proc. inn. only			
Total emp.	287.8	208.7	−27.5
HS share[b]	29.8	29.4	−0.4
No. firms	337	328	
Prod. and proc. inn.			
Total emp.	622.3	643.4	3.4
HS share[b]	34.4	35.2	0.8
No. firms	321	233	
Total			
Total emp.	278.9	230.0	−17.5
HS share[b]	30.2	30.3	0.1
No. firms	1875	2022	

Source: Encuesta Sobre Estrategias Empresariales; own calculations.
[a]Per cent for total employment and percentage points for HS share.
[b]Share of high-skilled labour (12 or more years of education) in per cent.

marginally improved (by 0.1 percentage points). Firms engaged in product or process innovation only reveal a drop in employment by more than a quarter, whereby their skill composition deteriorated as well. Major employment gains and skill upgrading are observed in firms engaged in both product and process innovations, where share of high-skilled labour increased by 0.8 percentage points (from 34.4% to 35.2%). Some employment gains and marginal skill upgrading were recorded also in the group of non-innovating firms.

This indicates that employment gains and skill upgrading can happen on both extremes of innovation spectrum. It remains to be explored to what extent these improvements in employment and skill composition are related to own innovation efforts and how much they rely on innovation externalities from other industries.

Results

This section presents the results of estimating models (1) and (3) on the impact of firms' own innovation and innovation spillovers from vertically linked industries on employment growth and changes in skill composition of Spanish firms.

Results for employment effects of innovation

Table 2 presents results for overall employment as a dependent variable. Regarding the effects of firms' own innovations, the results show that firms that engage either in both product and process innovation or in process innovations only benefit in terms of future employment growth. On the other side, product innovations only do not seem to have any impact on employment growth. This is somehow counterintuitive and in contrast to

Table 2. Impact of innovation spillovers on employment growth of Spanish manufacturing firms (period 1990–2008).

	(1)	(2)	(3)
own prod_inov only	0.006	0.005	0.005
	(0.76)	(0.60)	(0.69)
own proc_inov only	0.038***	0.037***	0.037***
	(6.32)	(6.10)	(6.01)
own prod & proc inov	0.040***	0.037***	0.037***
	(5.85)	(5.46)	(5.43)
All prod_inov spill	1.083***		
	(10.17)		
All proc_inov spill	−0.357***		
	(−4.47)		
All mkt & org_inov spill	0.035		
	(1.53)		
Manuf. prod_inov spill		1.844***	1.457***
		(3.51)	(2.72)
Manuf. proc_inov spill		−0.770*	−0.484
		(−1.79)	(−1.13)
Manuf. Mkt & org_inov spill		0.061	−0.010
		(0.51)	(−0.08)
Serv. prod_inov spill		2.143***	
		(4.15)	
Serv. proc_inov spill		0.384	
		(1.15)	
Serv. Mkt & org_inov spill		0.215#	
		(1.59)	
Kis prod_inov spill			2.033***
			(3.15)
Kis proc_inov spill			0.810
			(1.02)
Kis mkt & org_inov spill			0.525**
			(2.40)
Lkis prod_inov spill			2.427
			(0.74)
Lkis proc_inov spill			−5.061**
			(−1.98)
Lkis mkt & org_inov spill			0.300
			(0.28)
Firm size (log sales)	−0.008***	−0.008***	−0.010***
	(−4.64)	(−4.58)	(−5.39)
log TFP	−0.004**	−0.003*	−0.004**
	(−2.11)	(−1.89)	(−2.39)
Constant	0.135***	0.008	0.094
	(2.64)	(0.15)	(1.52)
Observations	16,615	16,615	16,615
R-squared	0.022	0.026	0.028

Notes: Dependent variable is annual growth rate of employment. All explanatory variables are lagged two years. The model includes sector and time fixed effects. Robust *t*-statistics in parentheses.

Source: Encuesta Sobre Estrategias Empresariales; Labour force survey, Eurostat; Community innovation survey, Eurostat; Input–Output Tables, Eurostat.

*Coefficients are significantly different from zero at 10%.

**Coefficients are significantly different from zero at 5%.

***Coefficients are significantly different from zero at 1%.

#Coefficients are marginally insignificant at 10%.

other findings (Harrison et al., 2014; Mairesse, 2008; Pianta, 2005) that product innovations are more likely to boost employment, while process innovations are more likely to have a labour-saving effect.

Regarding the innovation spillover effects, product innovation in vertically linked industries is shown to have a positive spillover effect on firms' future employment growth, while process innovation is shown to have a negative impact. In contrast, vertical spillovers from marketing and organisational innovation are insignificant. When vertical innovation spillovers are decomposed into those originating from manufacturing and those stemming from service industries, the results in column 2 show that the firms benefit from both sources of spillovers in case of product innovation. Spillovers from KIS product innovation seem to display the strongest effect on employment in user industries. Process innovations in vertically linked manufacturing industries still exert a negative effect, while process innovation in service industries does not have any impact. Decomposing innovation spillovers from service sectors into KIS and LKIS reveals that the whole effect originates from the former services. Interestingly, while vertical spillovers from marketing and organisational innovation are in general non-existent, they turn significant and positive for spillovers from KIS industries. These beneficial spillover effects of innovative KIS on employment in user manufacturing firms complement the results of studies that deal with knowledge spillovers from KIS and their facilitating role for innovation, productivity, and export performance of manufacturing firms (Doloreux & Shearmur, 2012). As far as spillovers from LKIS are concerned, process innovations in those services seem to negatively affect firms' employment growth.

Results for effects of innovation on skill composition

Table 3 present results for the effects of firms' own innovation and vertical innovation spillovers on changes in firms' skill composition using LPM and probit model. Both sets of results are fairly consistent in terms of the signs and significance of coefficients, which confirms that the LPM in our case indeed serves as a convenient approximation to the underlying linear response probability of changes in skill composition.

Results show that skill composition of Spanish manufacturing firms benefits from all types of firms' own innovation. The largest effect on skill upgrading is recorded when firms are engaged in process innovations only, followed by product and process innovations. In terms of innovation spillovers, we find no significant spillover effects on skill upgrading from manufacturing sectors, but strong and significant spillovers from service sectors. Specifically, we find that spillovers from product as well as organisational and marketing innovations in service sector exert a positive impact on skill upgrading, while there are negative spillovers from process innovations. When disaggregating the service sector, results show that most of the innovation spillovers stem from the product innovations and organisational and marketing innovations in the KIS and no effect from innovation in the LKIS. These results confirm again the significant role of KIS in economies where the sectors are intensively interlinked.

Concluding remarks

Strengthening the investment in innovation is at the core of European Union countries' 'growth and jobs policy agenda'. Nonetheless, translating innovation into market success is not an easy task and much less so is the creation of new employment opportunities through innovation. Addressing the acute problem of high unemployment is in the vital

Table 3. Impact of innovation spillovers on high-skilled labour shares' increases of Spanish manufacturing firms (period 1990–2008).

	Probit			OLS		
	(1)	(2)	(3)	(4)	(5)	(6)
own prod_inov only	0.112*	0.111*	0.112*	0.042	0.042	0.042
	(1.66)	(1.65)	(1.66)	(1.61)	(1.60)	(1.61)
own proc_inov only	0.312***	0.309***	0.307***	0.121***	0.120***	0.119***
	(5.85)	(5.79)	(5.75)	(5.87)	(5.82)	(5.77)
own prod & proc inov	0.259***	0.260***	0.259***	0.100***	0.101***	0.100***
	(4.53)	(4.54)	(4.52)	(4.55)	(4.55)	(4.53)
All prod_inov spill	3.180***			1.209***		
	(4.03)			(3.99)		
All proc_inov spill	−3.463***			−1.308***		
	(−6.14)			(−6.10)		
All mkt & org_inov spill	1.631***			0.625***		
	(9.25)			(9.28)		
Manuf. prod_inov spill		−3.725	−3.319		−1.466	−1.306
		(−1.03)	(−0.91)		(−1.06)	(−0.94)
Manuf. proc_inov spill		1.478	1.281		0.586	0.508
		(0.56)	(0.48)		(0.58)	(0.50)
Manuf. Mkt & org_inov spill		0.348	0.446		0.139	0.178
		(0.41)	(0.52)		(0.43)	(0.55)
Serv. prod_inov spill		8.194*			3.160*	
		(1.82)			(1.83)	
Serv. proc_inov spill		−8.834***			−3.368***	
		(−3.11)			(−3.12)	
Serv. Mkt & org_inov spill		3.063***			1.165***	
		(2.94)			(2.94)	
Kis prod_inov spill			17.909#			6.942#
			(1.41)			(1.42)
Kis proc_inov spill			−17.324#			−6.663#
			(−1.61)			(−1.63)

(Continued)

Table 3. Continued.

	Probit			OLS		
	(1)	(2)	(3)	(4)	(5)	(6)
Kis mkt & org_inov spill			3.769*			1.465*
			(1.64)[#]			(1.67)
Lkis prod_inov spill			3.878			1.224
			(0.07)			(0.06)
Lkis proc_inov spill			−6.716			−2.265
			(−0.12)			(−0.11)
Lkis mkt & org_inov spill			−3.968			−1.799
			(−0.14)			(−0.16)
Firm size (log empl.)	−0.031	−0.030	−0.030	−0.011	−0.011	−0.011
	(−0.95)	(−0.92)	(−0.92)	(−0.92)	(−0.88)	(−0.89)
log TFP	−0.010	−0.010	−0.009	−0.003	−0.003	−0.003
	(−0.49)	(−0.48)	(−0.45)	(−0.45)	(−0.45)	(−0.41)
Constant	0.090	0.143	0.089	0.528***	0.548***	0.528***
	(0.26)	(0.29)	(0.19)	(3.93)	(2.94)	(2.87)
Observations	4757	4757	4757	4757	4757	4757
R-squared	0.026	0.027	0.027	0.035	0.036	0.037

Notes: Dependent variable is a dummy variable, where 1 indicates increase in high-skilled labour shares over the last four-year period and 0 indicates lack thereof. All explanatory variables are lagged two years. The model includes sector and time fixed effects. Robust *t*-statistics in parentheses.
Source: Encuesta Sobre Estrategias Empresariales; Labour force survey, Eurostat; Community innovation survey, Eurostat; Input–Output Tables, Eurostat.
*Coefficients are significantly different from zero at 10%.
**Coefficients are significantly different from zero at 5%.
***Coefficients are significantly different from zero at 1%.
[#]Coefficients are marginally insignificant at 10%.

interest the European economies, especially those where recovery is delayed and threatens the socio-economic stability. Labour market policy instruments and measures to boost economic growth are perceived as the main levers for alleviating the problem, while the impacts of innovation on jobs are much less explored.

The paper contributes to narrowing this gap by considering multidimensional effects of innovation on employment and skills composition. So far, studies have addressed the issue of innovation impact on employment primarily from the perspective of changes within a firm, industry, or sector. However, this viewpoint neglects the links between actors from different sectors and how their innovation activity influences employment in vertically linked industries. Our analysis captures these effects by accounting for knowledge externalities (innovation spillovers) based on endogenous growth theory. This is the main added value of the paper and its main contribution to theory. To empirically test this proposition, we estimated the impact of innovation spillovers from vertically linked industries on employment and skills change in vertically linked manufacturing firms using representative samples of micro data for Spanish manufacturing firms in a longer time period (1990–2008).

We find that spillover effects from innovation on employment and skills differ depending on the type of innovation and the sector from which spillovers originate. Product innovation in manufacturing and in services displays statistically significant positive effect on employment in vertically linked manufacturing firms with spillovers from KIS showing the strongest impact. Process innovation spillovers from vertically linked manufacturing industries exert a negative effect on employment, while there is no such effect from service industries' process innovation. In the case of marketing and organisational innovations, spillovers on employment in manufacturing occur only from vertically linked KIS. Regarding the spillover effects on skills, our analysis reveals that in manufacturing, no type of innovation seems to bring spillovers on skill upgrading. In services, spillovers from product and particularly from organisational and marketing innovations exert a positive impact on skill upgrading in manufacturing with KIS being the main driver of such changes. Overall, the results suggest that innovation spillovers from vertically linked industries provide an important source of positive externalities to employment growth and skill upgrading of firms in the user industries with a prominent role of KIS that confirms our hypothesis. Owing to the deficient data for employment in service firms, our paper focused on innovation spillovers on manufacturing employment only. Taking into account that service industries dominate the employment landscape and new jobs creation in all European economies, it is necessary to expand future research in such a way to capture innovation spillovers on employment and skills change in service industries as well.

Finally, the results of the analysis concerning the relation between innovation and employment and skills are relevant also from the perspective of public policy. The observed importance of innovative KIS for job creation and skill upgrading in user industries via spillovers suggests that those services need to be more vigorously promoted in European Union industrial policy strategy and in the European Union 2020 Strategy. As advocated by the High-level group on business services, these services[8] will play a central role in the reindustrialisation of Europe, both through the provision of innovative and productive services to other firms, and through the servitisation of manufacturing. Accordingly, the High-level group asks for a revision of the European Union 2020 Strategy so as to explicitly recognise and support the role of business services (for an overview of seven key actions, see European Commission, 2014). Another relevant question for policy design arises concerning the scope of innovation policy objectives. Should the innovation policy, besides productivity drive, more directly pursue other goals as well, such as employment? Is it opportune to look for direct employment effects only in relation to social innovation when unemployment is looming large in several European Union economies?

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Notes

1. See Djellal and Gallouj (2007) and Evangelista and Savona (2010) for a detailed overview and discussion of literature and approaches to analysing the nexus between innovation and employment in services.
2. For details on different definitions of KIS that intensivly use knowledge, see Rubalcaba and Kox (2007). Throughout the article, we use the term knowledge-intensive services (KIS) to denote market knowledge-intensive services. For definition of sub-sectors of KIS, see Schricke, Zenker, and Stahlecker (2012).
3. Manufacturing and service industries are grouped into four categories: science-based, specialised suppliers, scale and information-intensive, and supplier-dominated activities.
4. The analysis uses the term business services.
5. Note that our firm-level data contain information on technological innovation (product, process) only, but no information on non-technological innovation (organisational or marketing).
6. Services are mainly aggregated into KIS and LKIS based on the share of tertiary educated persons at NACE 2-digit level. For a detailed list of KIS and LKIS, see Eurostat http://epp.eurostat.ec.europa.eu/cache/ITY_SDDS/Annexes/htec_esms_an2.pdf.
7. Total factor productivity is estimated using the Olley and Pakes (1996) methodology.
8. The term business services denotes KIS and less KIS (e.g. operational support services, such as office leasing, or industrial cleaning) (European Commission, 2014).

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